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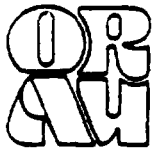

Prepared by
Oak Ridge Associated
Universities

Prepared for
Division of Fuel
Cycle and
Material Safety

U.S. Nuclear
Regulatory
Commission

RADIOLOGICAL SURVEY OF KRESS CREEK WEST CHICAGO, ILLINOIS

P.W. Frame

Prepared by

Radiological Site Assessment Program
Manpower Education, Research, and Training Division
Oak Ridge Associated Universities
Oak Ridge, Tennessee 37830

FINAL REPORT

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Project Staff

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OF
KRESS CREEK
West Chicago, Illinois

P.W. Frame, J.D. Berger, W.O. Helton,
C.W. Kuechle, S.E. Tench, C.F. Weaver, R.D. Condra

INTRODUCTION

Between 1931 and 1937 a thorium ore processing facility was operated in West Chicago, Illinois by Lindsay Light and Chemical Company. The principal activity at this site initially was extraction of thorium for use in the manufacture of gas mantles. Later operations included the recovery of rare earths also present in the ores. The resulting solid wastes were accummulated in two large piles on the plant site. Over the years, precipitation-induced runoff has transported small quantities of wastes from these piles into a nearby storm sewer and drainage ditch. From there the wastes were carried into Kress Creek, where they have been deposited at numerous locations downstream from the storm sewer and ditch outfall.

In 1974, the present owner of the facility, Kerr-McGee Corporation, began cleanup activities to decommission the facility. At the request of the Nuclear Regulatory Commission, Argonne National Laboratory (ANL) conducted a radiological evaluation of thorium residues in the West Chicago area beginning in 1976.[1] The study of the Kress Creek region consisted primarily of direct radiation measurements between the outfall of the sewer runoff and the juncture of Kress Creek with the DuPage River (West Branch). Radiation levels up to 150 μrem/h were reported for several locations up to 1 km downstream from the outfall. The ANL study estimated that at least 80% of the thorium waste in the Creek was deposited in the upper one-third of its course between the sewer outfall and the DuPage River. A 1977 aerial radiological survey by EG&G confirmed the

presence of thorium residues along the Creek.[2] Soil and sediment samples collected in 1980 by Region V of the Environmental Protection Agency (EPA) indicated that distribution of the waste was 'much more extensive' than indicated by the ANL study.[3] EPA also identified the primary radionuclides in the waste as thorium-232 and thorium-228 in essentially secular equilibrium. On July 29, 1981 the Radiological Site Assessment Program of Oak Ridge Associated Universities, Oak Ridge, Tennessee, conducted additional sampling and monitoring of Kress Creek to further characterize its radiological status.

SITE DESCRIPTION

Kress Creek is located near West Chicago in DuPage County, Illinois (see Figure 1). It originates on property of the Fermi National Accelerator Laboratory. After leaving the boundaries of the Fermi site, the Creek passes under the tracks of the Elgin, Joliet, and Eastern Railroad, approximately 0.3 km south of Roosevelt Road. Just past this point, a storm sewer outfall and trackside drainage ditch from the area of the Kerr-McGee facility empty into the Creek. From this point, Kress Creek flows approximately 2 km in a southeasterly direction until it joins the West Branch of the DuPage River (see Figures 2 & 3). The Creek ranges from 3 to 15 meters in width and 0.5 to 2 meters in depth. The banks range from low and flat to high and steep. During periods of average rainfall the Creek is relatively slow moving; however, eroded areas of the banks indicate that the flow varies and the Creek occassionally overflows its banks. The stream bed is sand and rock with some regions of hard clay. Aquatic vegetation is sparse, although at the time of the survey there was considerable algal growth. Sections of the banks are covered with heavy vegetation. A small population of carp, suckers, and shiners inhabits the Creek (a fish kill had occurred just prior to the survey). Accumulations of greyish-colored thorium-containing residues are visible in the sediments in slower moving sections of the Creek, particularly near the storm runoff outfall.

SURVEY OBJECTIVES

This survey was performed to obtain additional information concerning radionuclide concentrations in the surface soil and sediment along Kress Creek.

SURVEY PROCEDURES

Sampling Techniques and Locations

Surface (0-15cm) soil samples were collected just above the high-water mark along the Creek bank. A garden trowel was used for soil collection after the surface was cleared of vegetation cover. Sediment samples were collected from the stream bed, also by using a small trowel. Samples of approximately 1 kg were collected at each location. Soil samples were sealed in plastic bags and then placed in cardboard ice cream cartons. Sediment samples were collected in 1 liter wide-mouthed plastic bottles. Twenty-six systematic samples of both soil and sediment were obtained at approximately 100 meter intervals between the storm runoff outfall into Kress Creek and the West Branch of the DuPage River (see Figure 3). Seven samples of each were collected upstream of the outfall. In addition to the systematic samples, eleven biased bank soil samples and ten biased sediment samples were obtained at some of the locations where elevated radiation levels exist along the Creek bank. Elevated areas were generally determined from the Argonne National Laboratory report, and maximum levels within these areas were located using NaI scintillation probes with portable countrate meters. Exposure rates at 1 meter above the surface were noted at soil sampling locations for comparison with ANL data. Five "off-site" soil samples were also obtained in the West Chicago area, to serve as baselines for comparison.

Sample Analysis and Interpretation of Data

Samples were returned to laboratories in Oak Ridge, Tennessee for analysis. Gamma spectrometry was performed for Th-232, Th-228, Ra-226, U-235 and U-238. Procedures are described in further detail in Appendix A.

RESULTS

Radionuclide concentrations in bank soil samples collected along Kress Creek are summarized in Table 1. Upstream samples were comparable to the baseline samples from the West Chicago area. At the storm runoff outfall and downstream to the juncture with the West Branch of the DuPage River, all samples contained elevated concentrations of Th-232 and Th-228. Concentrations do not appear to follow any pattern of distribution; the maximum levels - 166 pCi/g of Th-232 and 105 pCi/g of Th-228 were noted approximately 600 meters downstream from the outfall at sampling point 20. Ra-226, U-235, and U-238 concentrations ranged from 0.32 to 2.9 pCi/g, <0.01 to 1.7 pCi/g, and <12 to 44 pCi/g respectively. These ranges generally exceeded the levels in baseline soils but not to the extent as did Th-232 and Th-228 levels.

Sediment samples (see Table 2) also contained elevated levels of Th-232 and Th-228 downstream from the outfall. Concentrations did not follow a noticeable pattern and highest sediment and soil concentrations were not noted at the same locations. The maximum sediment concentrations of Th-232 (283 pCi/g) and Th-228 (187 pCi/g) were found at location 10, approximately 100 meters below the outfall. Other noteably high concentrations were found at sampling locations 11 and 32. Of the 6 upstream sediment samples only the sample from location 3 contained radionuclide concentrations significantly above baseline soils. These concentrations were 3.8 pCi/g of Th-232, 5.1 pCi/g of Th-228, and 5.7 pCi/g of Ra-226.

Maximum radionuclide concentrations noted in both soil and sediment exceeded the highest levels reported by EPA.[3] The ratios of Th-232 to Th-228 concentrations in many of the higher level samples exceeded 1 (most were between 1.2 and 1.5). This indicates that sufficient time has not passed, since disturbance of the distributions during processing, to allow the series to completely reachieve its normal equilibrium state.

High concentrations in soil correlate with exposure rates (see Figure 4). The maximum exposure rate of 140 μR/hr was noted at location 24. Levels were slightly lower than those presented in the Argonne report, but were in relative agreement with the findings of that survey.[1]

SUMMARY

Thorium containing residues from the Kerr McGee (formerly Lindsay Light and Chemical) facility in West Chicago, Illinois have entered nearby Kress Creek via storm runoff. These residues have been deposited in bottom sediments and bank soils for a distance of approximately 2 kilometers below the storm sewer outfall. The activity concentrations of the various radionuclides are shown in Table 1 and 2.

It should be noted that the radionuclide concentrations presented in this report are not necessarily the maximum levels or representative of the average levels along the Creek. This is particularly true for the bottom sediments since it was not possible to locate areas of maximum direct radiation levels attributable to radioactive materials below the water surface. Also, this study did not attempt to determine the extent of thorium residue deposits beyond the juncture of Kress Creek and the West Branch of the DuPage River.

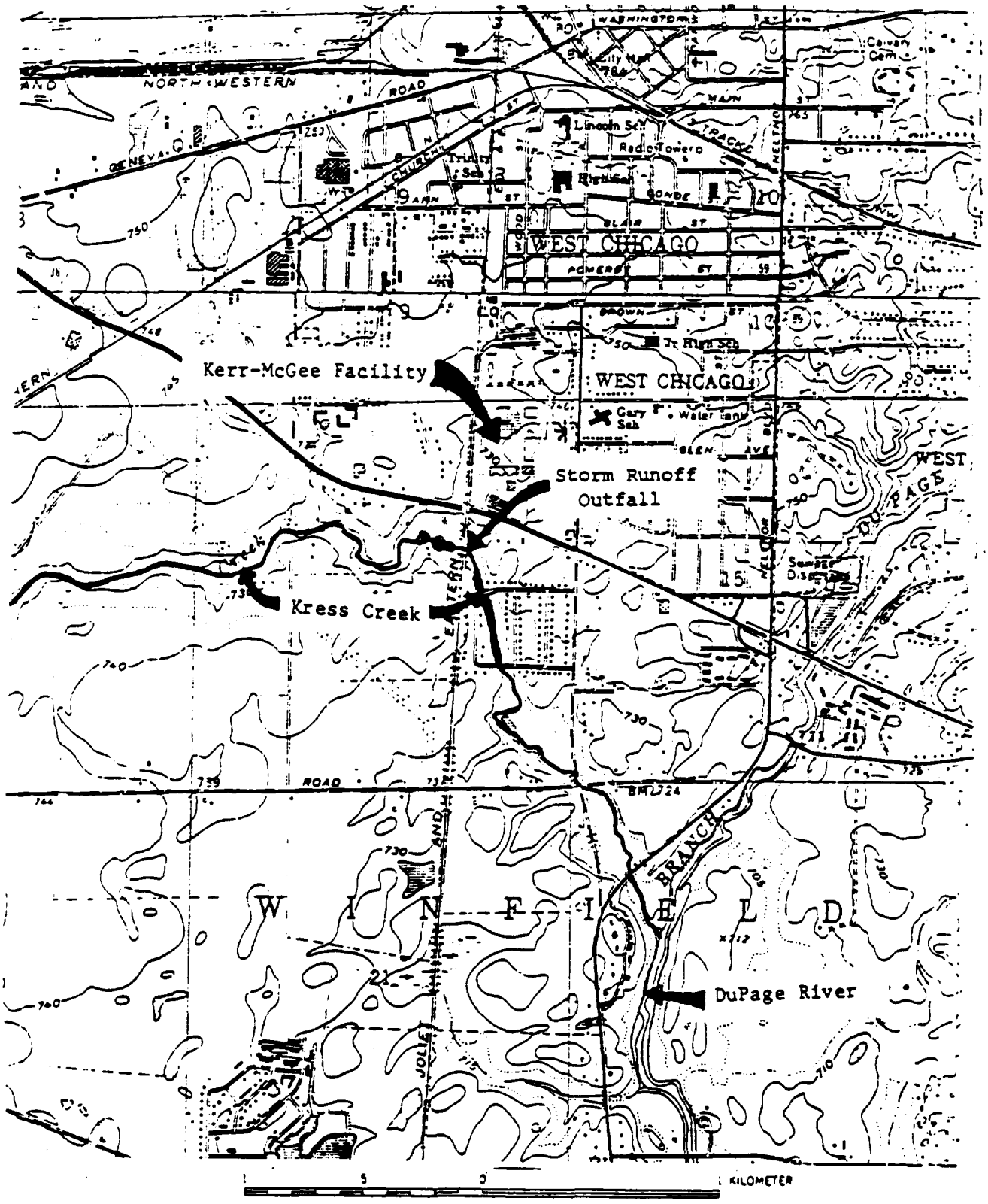

FIGURE 1. West Chicago, Illinois Area Showing Location of Kress Creek.

FIGURE 2. Aerial Photograph of Kress Creek Area.

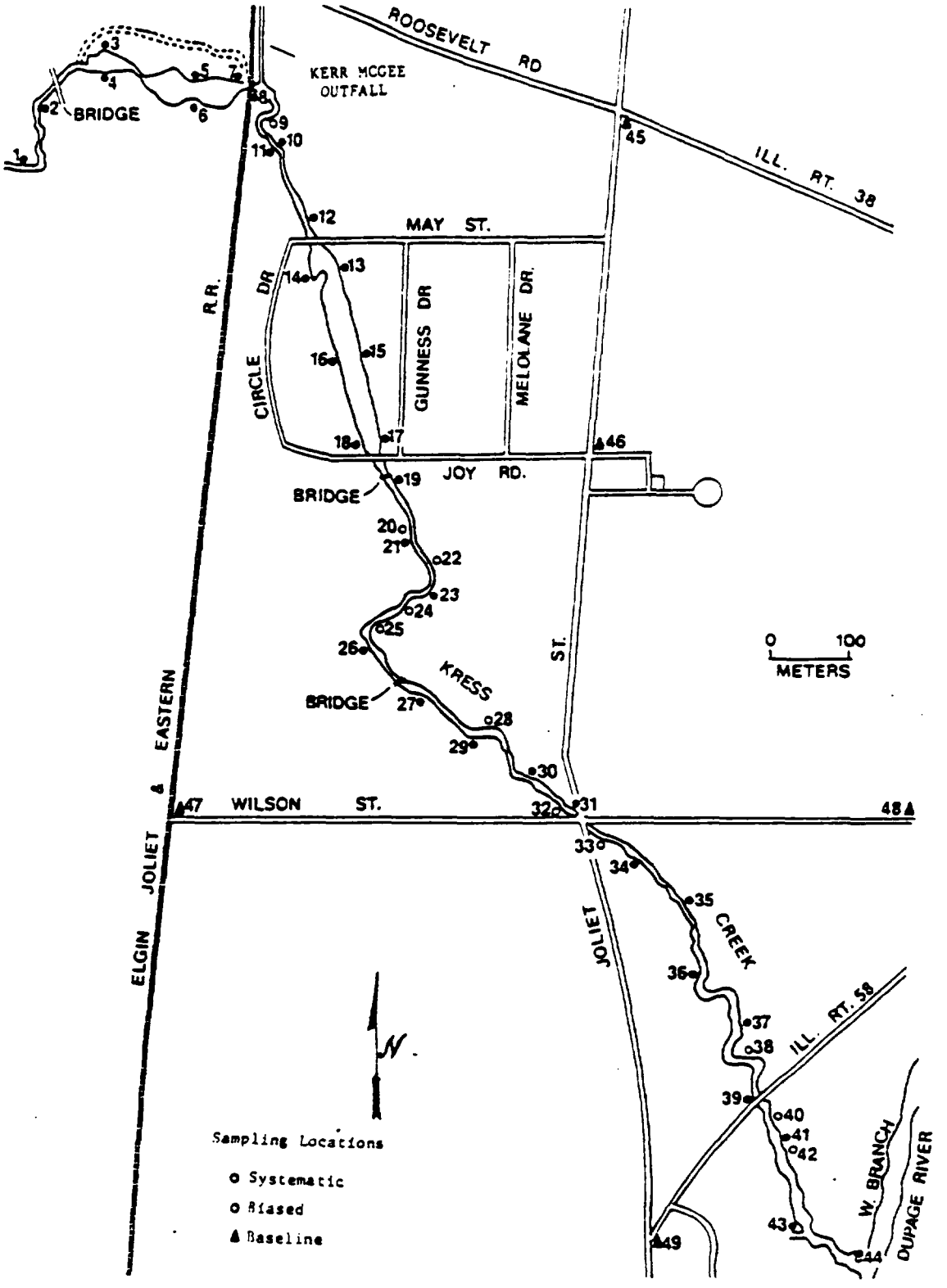

FIGURE 3. Plan View of Kress Creek, Indicating Sampling and Measurement Points.

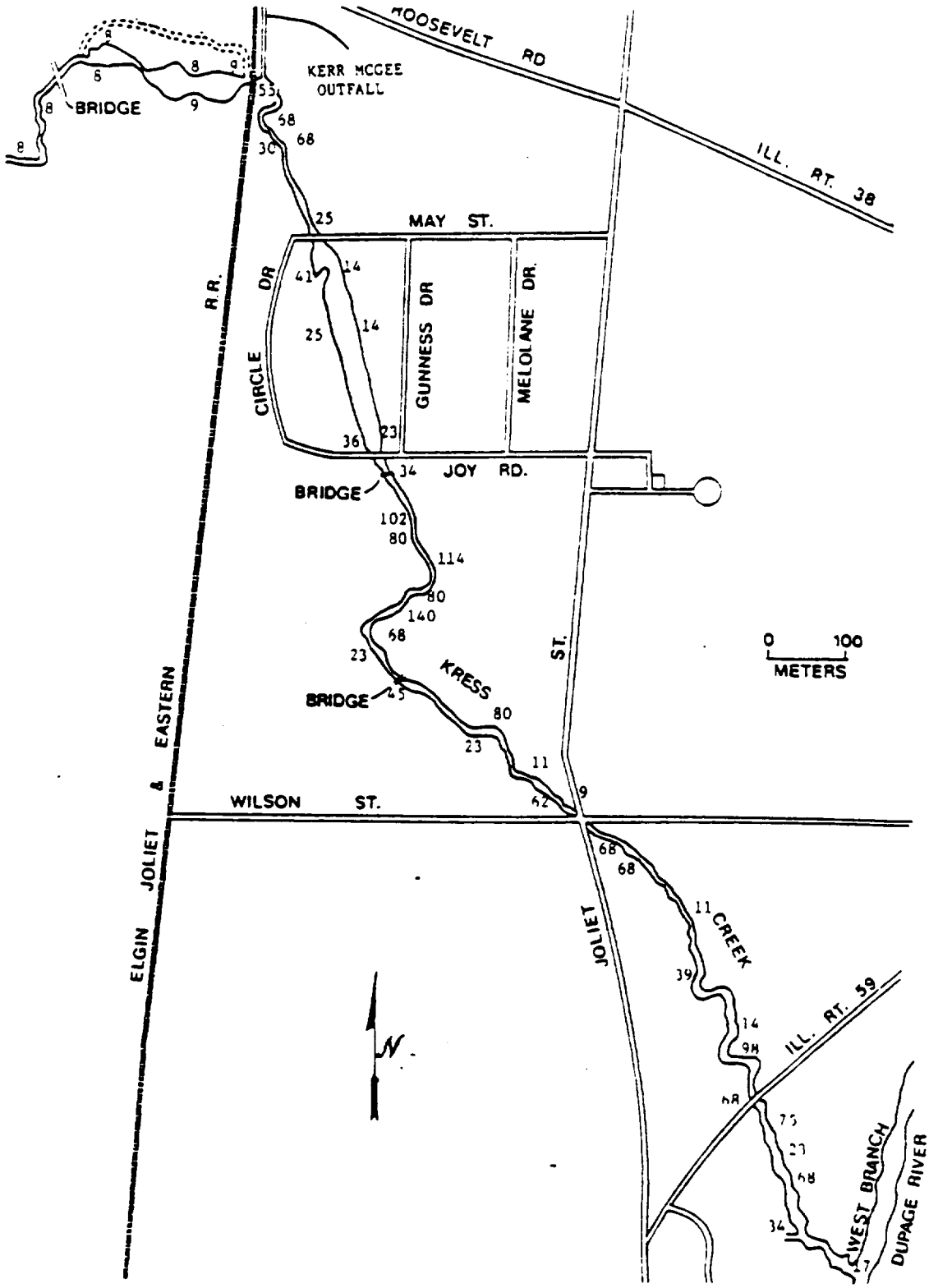

FIGURE 4. Plan View of Kress Creek Indicating Exposure Rates (uR/h) at Sampling Points.

TABLE 1

RADIONUCLIDE CONCENTRATIONS IN BANK SOILS ALONG KRESS CREEK

Sample No.	Type and Location[a]	Radionuclide Concentration (pCi/g)					Exposure Rate at 1 meter above surface (μR/hr)
		Th-232	Th-228	Ra-226	U-235	U-238	
1	Systematic - upstream	1.3 ± 0.5[b]	0.39 ± 0.48	1.2 ± 0.3	0.16 ± 0.11	< MDA[c]	8
2	Systematic - upstream	<0.54	<0.27	1.1 ± 0.3	0.15 ± 0.13	< MDA	8
3	Systematic - upstream	1.0 ± 0.4	<0.27	1.5 ± 0.3	0.16 ± 0.12	< MDA	8
4	Systematic - upstream	1.1 ± 0.4	0.75 ± 0.30	1.1 ± 0.2	<0.08	< MDA	8
5	Systematic - upstream	1.1 ± 0.3	0.84 ± 0.30	0.89 ± 0.24	<0.05	< MDA	8
6	Systematic - upstream	0.42 ± 0.32	0.27 ± 0.30	0.85 ± 0.18	0.09 ± 0.07	< MDA	9
7	Systematic - upstream	0.99 ± 0.73	1.2 ± 0.5	0.93 ± 0.34	<0.07	< MDA	9
8	Systematic - at outfall	49.8 ± 2.4	39.6 ± 1.8	2.8 ± 0.7	1.1 ± 0.4	< MDA	55
9	Biased - downstream	82.4 ± 1.9	26.8 ± 1.5	2.4 ± 0.6	<0.16	20 ± 19	68
10	Systematic - downstream	7.7 ± 1.1	5.1 ± 0.9	0.78 ± 0.43	<0.19	<MDA	68
11	Systematic - downstream	5.3 ± 0.9	3.9 ± 0.6	2.0 ± 0.3	0.15 ± 0.16	<MDA	30
12	Systematic - downstream	9.6 ± 1.2	8.1 ± 0.9	1.4 ± 0.4	<0.03	<MDA	25
13	Systematic - downstream	1.7 ± 0.4	1.3 ± 0.4	1.7 ± 0.3	0.16 ± 0.13	<MDA	14
14	Systematic - downstream	7.2 ± 1.1	5.4 ± 0.9	1.5 ± 0.4	0.41 ± 0.23	<MDA	41
15	Systematic - downstream	6.1 ± 0.8	3.6 ± 0.9	2.1 ± 0.5	<0.11	<MDA	14
16	Systematic - downstream	3.9 ± 0.8	3.6 ± 0.6	1.1 ± 0.3	0.12 ± 0.17	<MDA	25
17	Systematic - downstream	6.9 ± 1.0	5.4 ± 0.9	1.4 ± 0.3	<0.13	<MDA	23
18	Systematic - downstream	12.0 ± 1.3	9.6 ± 0.9	1.4 ± 0.5	0.20 ± 0.24	<MDA	36
19	Systematic - downstream	17.9 ± 1.5	15.3 ± 1.2	0.88 ± 0.49	<0.02	44 ± 27	34
20	Biased - downstream	166 ± 5	105 ± 3	2.9 ± 1.2	1.7 ± 0.7	<MDA	102
21	Systematic - downstream	70.6 ± 2.8	50.1 ± 2.1	1.5 ± 0.8	0.70 ± 0.40	<MDA	80
22	Biased - downstream	94.2 ± 3.3	60.6 ± 2.1	2.1 ± 0.9	0.92 ± 0.52	<MDA	114
23	Systematic - downstream	22.8 ± 1.7	16.5 ± 1.2	<0.35	<0.01	<MDA	80
24	Biased - downstream	60.7 ± 2.7	40.2 ± 2.1	2.3 ± 0.7	0.97 ± 0.52	<MDA	140
25	Biased - downstream	60.9 ± 2.8	13.5 ± 2.1	<0.54	1.1 ± 0.5	<MDA	68
26	Systematic - downstream	2.0 ± 0.5	1.2 ± 0.3	0.94 ± 0.22	<0.06	<MDA	23
27	Systematic - downstream	11.9 ± 1.2	10.5 ± 0.9	0.76 ± 0.40	0.27 ± 0.20	<MDA	45
28	Biased - downstream	25.3 ± 1.8	15.6 ± 1.2	0.32 ± 0.12	0.30 ± 0.30	<MDA	80
29	Systematic - downstream	12.4 ± 1.1	10.8 ± 0.9	0.78 ± 0.30	0.24 ± 0.19	<MDA	23
30	Systematic - downstream	1.5 ± 0.4	1.5 ± 0.5	0.91 ± 0.22	<0.07	<MDA	11
31	Systematic - downstream	1.2 ± 0.4	1.1 ± 0.3	0.76 ± 0.23	0.12 ± 0.15	<MDA	9
32	Biased - downstream	12.5 ± 1.2	9.3 ± 0.9	1.1 ± 0.4	<0.12	<MDA	62

Table 1, cont.

Sample No.	Type and Location[a]	Radionuclide Concentration (pCi/g)					Exposure Rate at 1 meter above surface (μR/hr)
		Th-232	Th-228	Ra-226	U-235	U-238	
33	Biased - downstream	84.0 ± 2.9	63.9 ± 2.4	0.98 ± 0.68	<0.25	<MDA	68
34	Systematic - downstream	14.4 ± 1.2	9.3 ± 0.9	1.1 ± 0.5	0.19 ± 0.21	<MDA	68
35	Systematic - downstream	2.8 ± 0.5	2.9 ± 0.5	0.45 ± 0.23	0.12 ± 0.12	<MDA	11
36	Systematic - downstream	12.6 ± 1.3	9.3 ± 0.9	1.0 ± 0.5	0.35 ± 0.22	<MDA	39
37	Systematic - downstream	1.5 ± 0.4	2.5 ± 0.4	1.1 ± 0.2	<0.02	<MDA	14
38	Biased - downstream	31.2 ± 2.1	24.3 ± 1.5	1.9 ± 0.9	0.52 ± 0.43	<MDA	98
39	Systematic - downstream	9.2 ± 1.1	7.2 ± 0.9	0.93 ± 0.36	0.25 ± 0.24	<MDA	68
40	Biased - downstream	12.0 ± 1.2	10.5 ± 0.9	1.7 ± 0.4	<0.12	<MDA	75
41	Systematic - downstream	4.6 ± 0.7	3.9 ± 0.6	1.5 ± 0.3	0.30 ± 0.16	<MDA	23
42	Biased - downstream	23.9 ± 1.7	16.8 ± 1.2	1.4 ± 0.5	0.31 ± 0.28	<MDA	68
43	Systematic - downstream	16.6 ± 1.4	10.8 ± 0.9	0.85 ± 0.37	<0.02	<MDA	34
44	Systematic - downstream	4.4 ± 0.8	4.8 ± 0.9	0.81 ± 0.32	0.84 ± 0.14	<MDA	17
45	Off site - baseline	0.95 ± 0.38	0.54 ± 0.33	1.1 ± 0.3	0.06 ± 0.09	<MDA	not measured
46	Off site - baseline	0.67 ± 0.32	0.78 ± 0.21	0.73 ± 0.18	<0.05	<MDA	not measured
47	Off site - baseline	0.59 ± 0.31	0.30 ± 0.18	0.53 ± 0.12	<0.04	<MDA	not measured
48	Off site - baseline	0.80 ± 0.33	0.75 ± 0.21	0.48 ± 0.19	<0.06	<MDA	not measured
49	Off site - baseline	0.94 ± 0.42	0.63 ± 0.30	0.60 ± 0.16	0.11 ± 0.08	<MDA	not measured

a Refer to Figure 3

b Error is 2σ based on counting statistics only

c MDA for U-238 ranges from 12-18 pCi/g

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN KRESS CREEK SEDIMENTS

Sample No.	Type and Location[a]	Radionuclide Concentration (pCi/g)				
		Th-232	Th-228	Ra-226	U-235	U-238
1	Systematic - upstream	1.1 ± 0.4[b]	1.6 ± 0.4	1.2 ± 0.3	0.08 ± 0.11	<MDA[c]
2	Systematic - upstream	0.32 ± 0.34	0.69 ± 0.24	0.68 ± 0.15	0.09 ± 0.13	<MDA
3	Systematic - upstream	3.8 ± 1.7	5.1 ± 1.5	5.7 ± 1.1	<0.46	<MDA
4	Systematic - upstream	0.61 ± 0.25	0.54 ± 0.27	0.47 ± 0.14	0.15 ± 0.10	<MDA
5	Systematic - upstream	1.7 ± 0.4	1.0 ± 0.4	0.89 ± 0.23	<0.02	<MDA
6	Systematic - upstream	0.39 ± 0.24	0.63 ± 0.21	0.75 ± 0.14	0.17 ± 0.08	<MDA
7	Systematic - upstream	0.82 ± 0.38	1.4 ± 0.3	1.6 ± 0.3	<0.05	<MDA
8	Systematic - at outfall	1.7 ± 0.5	0.84 ± 0.54	1.3 ± 0.2	0.19 ± 0.12	<MDA
9	Biased - downstream	75.8 ± 2.6	77.7 ± 2.1	3.6 ± 0.8	0.40 ± 0.43	<MDA
10	Systematic - downstream	283 ± 4	187 ± 4	6.8 ± 1.1	<0.30	<MDA
11	Systematic - downstream	168 ± 4	132 ± 4	3.8 ± 1.1	0.96 ± 0.61	<MDA
12	Systematic - downstream	9.3 ± 1.0	11.1 ± 0.9	1.8 ± 0.3	0.31 ± 0.11	<MDA
13	Systematic - downstream	3.0 ± 0.6	2.0 ± 0.5	1.0 ± 0.2	0.13 ± 0.13	<MDA
14	Systematic - downstream	6.6 ± 0.9	6.0 ± 0.6	1.8 ± 0.3	0.15 ± 0.18	<MDA
15	Systematic - downstream	4.8 ± 0.9	5.7 ± 0.6	1.4 ± 0.3	0.28 ± 0.23	<MDA
16	Systematic - downstream	6.3 ± 1.0	5.7 ± 0.9	1.5 ± 0.4	<0.03	<MDA
17	Systematic - downstream	2.5 ± 0.7	2.7 ± 0.5	0.32 ± 0.35	0.31 ± 0.16	<MDA
18	Systematic - downstream	7.6 ± 1.0	7.2 ± 0.9	0.80 ± 0.32	<0.10	<MDA
19	Systematic - downstream	18.7 ± 1.4	15.9 ± 1.2	1.9 ± 0.5	0.27 ± 0.33	<MDA
20	Biased - downstream	29.8 ± 1.6	27.3 ± 1.2	1.5 ± 0.5	0.29 ± 0.28	<MDA
21	Systematic - downstream	13.4 ± 1.1	12.3 ± 0.9	1.2 ± 0.4	0.14 ± 0.18	<MDA
22	Biased - downstream	5.5 ± 0.3	5.1 ± 0.3	0.58 ± 0.10	<0.04	<MDA
23	Systematic - downstream	13.1 ± 1.0	12.0 ± 0.9	0.71 ± 0.27	<0.01	<MDA
24	Biased - downstream	24.6 ± 1.6	24.6 ± 1.5	0.77 ± 0.49	0.20 ± 0.29	<MDA
25	Biased - downstream	8.5 ± 0.9	9.9 ± 0.9	1.1 ± 0.4	<0.09	<MDA
26	Systematic - downstream	<0.54	1.2 ± 0.3	1.1 ± 0.2	0.13 ± 0.13	<MDA
27	Systematic - downstream	34.6 ± 1.6	28.2 ± 1.2	0.83 ± 0.51	<0.02	<MDA
28	----------	----------	no sample taken	----------	----------	----------
29	Systematic - downstream	5.1 ± 0.7	4.8 ± 0.6	0.85 ± 0.24	0.14 ± 0.13	<MDA
30	Systematic - downstream	3.4 ± 0.6	4.5 ± 0.6	0.67 ± 0.22	<0.01	<MDA
31	Systematic - downstream	1.1 ± 0.3	0.75 ± 0.27	0.51 ± 0.15	0.20 ± 0.11	<MDA
32	Biased - downstream	195 ± 5	141 ± 3	2.3 ± 1.1	0.84 ± 0.59	<MDA

Table 2, cont.

Sample No.	Type and Location[a]	Radionuclide Concentration (pCi/g)				
		Th-232	Th-228	Ra-226	U-235	U-238
33	Biased - downstream	1.6 ± 0.5	1.5 ± 0.4	1.0 ± 0.2	<0.02	<MDA
34	Systematic - downstream	2.2 ± 0.4	2.4 ± 0.4	0.84 ± 0.18	<0.06	<MDA
35	Systematic - downstream	2.0 ± 0.4	1.1 ± 0.3	0.67 ± 0.16	0.13 ± 0.13	<MDA
36	Systematic - downstream	2.3 ± 0.5	2.4 ± 0.4	0.68 ± 0.21	<0.C1	<MDA
37	Systematic - downstream	1.3 ± 0.6	1.1 ± 0.4	1.0 ± 0.3	0.10 ± 0.12	<MDA
38	Biased - downstream	18.6 ± 1.4	15.6 ± 1.2	<0.31	0.56 ± 0.26	<MDA
39	Systematic - downstream	1.7 ± 0.4	1.3 ± 0.3	0.90 ± 0.19	0.12 ± 0.10	<MDA
40	Biased - downstream	2.1 ± 0.5	2.5 ± 0.4	1.1 ± 0.2	<0.06	<MDA
41	Systematic - downstream	3.0 ± 0.6	2.5 ± 0.4	1.5 ± 0.3	0.38 ± 0.18	<MDA
42	Biased - downstream	7.1 ± 0.9	6.6 ± 0.6	0.43 ± 0.31	<0.09	<MDA
43	Systematic - downstream	4.8 ± 0.6	4.8 ± 0.6	0.84 ± 0.23	<0.01	<MDA
44	Systematic - downstream	2.4 ± 0.4	2.5 ± 0.4	0.33 ± 0.22	<0.09	<MDA

a Refer to Figure 3
b Error is 2 σ based on counting statistics only
c MDA for U-238 ranges from 12-18 pCi/g

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2 P.K. Boyns, W. Frankhauser, T.J. Headricks, and R. Shippman, Aerial Radiological Survey of West Chicago, Illinois, October 1977, Edgerton, Germeshausen, and Grier, EFF-1183-1730.

3. Letter, D. Kee (EPA) to A.B. Davis (NRC), re. EPA analysis of Soil, Sediment and Water From Kress Creek, January 29, 1981.

APPENDIX A

Instrumentation and Analytical Procedures

Gamma Scintillation Measurements

Measurements of gamma radiation levels were performed using a Victoreen Thyac III Model 490 portable ratemeter with a Victoreen Model 489-55 gamma scintillation probe containing a 3.2 cm x 3.8 cm NaI(Tl) scintillation crystal. Count rates (c/m) were converted to exposure levels (μR/h) using a factor of 440 c/m = 1 μR/h. This factor was determined by comparing the response of the scintillation detector with that of a pressurized ionization chamber to gamma photons from natural thorium.

Soil and Sediment Samples

Samples were dried at 120°C, finely ground, mixed, and a portion placed in a one-liter Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 400 to 600 grams of soil. The beakers were capped but not sealed. Net soil weights were determined and the samples counted using a 23% Ge(Li) detector (Princeton Gamma Tech) coupled to a Nuclear Data Model ND66 pulse height analyzer. The following energy peaks were used for determination of the radionuclides of concern:

Th-232 - 0.907 MeV from Ac-228*
Th-228 - 2.614 MeV from Tl-208
Ra-226 - 0.609 MeV from Bi-214
U-235 - 0.185 MeV
U-238 - 1.001 MeV from Pa-234m

Photopeaks were identified and peak and continuum region areas were determined using a Nuclear Data peak location computer routine available for the ND66 analyzer unit. Hand calculations were then performed for photopeaks of interest.

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* Secular equilibrium was assumed to exist between Th-232 and Ra-226, based on the time since processing was performed and confirmed by previous analyses.[3]

For U-235 analysis, contributions in the 0.185 MeV photopeak area from the 0.186 MeV Ra-226 gamma ray were subtracted. The ratio of the 0.186 MeV to 0.609 MeV peak intensities in a soil sample containing Ra-226, but no U-235, was determined and this ratio was multiplied by the intensity of the 0.609 MeV photopeak in each of the samples to determine the magnitude of this contribution.

Calibration and Quality Assurance

With the exception of the exposure rate conversion factor for portable gamma survey meters, all instruments were calibrated with NBS traceable standards. Quality control procedures included daily background and source measurements to confirm lack of malfunctions and non statistical deviations of equipment. The ORAU laboratory participates in the EPA Quality Assurance Program.